SIERRA

CARRIER FREQUENCY VOLTMETER

KS-15538

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KS-15538, LIST 5 CARRIER FREQUENCY VOLTMETER (RANGE: 2 TO 350 KILOCYCLES) DESCRIPTION (SIERRA ELECTRONIC CORPORATION)

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1. GENERAL

1.01 This section describes the KS-15538,L5 Carrier Frequency Voltmeter. This meter supplements the KS-15538,L4 Carrier Frequency Voltmeter and is intended for use generally where ac power is not available. The KS-15538,L4 and L5 meters are products of Sierra Electronics Division of Philco Corporation. The majority of the information in this section was obtained from the manufacturers instruction manual and is reprinted with the permission of the Sierra Electronics Division of Philco Corporation.

1.02 This selective frequency voltmeter is generally used for tests on N, O and ON carrier systems to measure the carrier power of the individual channels and determine the slope characteristics of the high-frequency line.

1.03 Table 1 lists the specifications for the meter and Table 2 lists the operating controls and indicators. Figure 1 shows a photograph of the voltmeter.

2. DESCRIPTION

2.01 The KS-15538,L5 Frequency Selective Voltmeter, is a fully transistorized, battery-operated instrument that measures voltages from 245 microvolts to 9.75 volts (−75 db to +22 db) in the frequency range of 2 KC to 350 KC. The voltmeter has a 250 cps bandwidth that makes it particularly useful for analyzing complex waveforms, determining carrier system levels, and checking amplitude modulation percentages. Special features include: a 20-pin Western Electric input connector for patching into telephone carrier systems, an internal oscillator for calibration purposes, and headphone jacks for audio monitoring.

2.02 A compact metal cabinet, 12 inches high, 7.5 inches wide and 7.5 inches deep, is used to house the instrument. The weight of the instrument, with batteries, is 16 pounds. The front panel contains all of the operating controls and is protected from damage by a metal cover

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that fastens in place by snaps. The function selector switch must be in off position before the cover can be installed, thereby preventing the possibility of battery discharge while the instrument is not in use.

2.03 The major portion of voltmeter circuitry is laid out on printed circuit boards and assembled into eight separate modules that are mounted on a main chassis by standoff insulators. Extensive shielding is provided for modules and components to prevent interaction between circuits.

2.04 The voltmeter is powered by seven size D1.5 volt cells. Either zinc-carbon or rechargeable nickel-cadmium cells may be used to provide up to 100 hours of operation. A two-pin female connector, located at the rear of the voltmeter cabinet, provides access for battery charging when nickel-cadmium cells are installed in the battery pack.

TABLE 1 — TABLE OF SPECIFICATIONS

Frequency Range:	2 kc to 350 kc
Input Level:	−70 dbm to +22 dbm
Temperature Range:	−10°C to +50°C (14°F to 122°F)
Frequency Accuracy :	±1 kc
Measurement Accuracy:	±1 db
Selective Voltmeter Bandpass:	500 cps (±250 cps), 3 db down 1200 cps, 30 db down 2000 cps, 60 db down
Audio Monitor Bandpass:	3.5 kc, 6 db down 6 kc, 20 db down
Direct Reading:	Dbm on 135-ohm and 600-ohm balanced or unbalanced lines. Voltage on 600-ohm lines only.
Spurious Response:	Greater than 50 db
Intermediate Frequencies:	
1st IF	1310 kc
2nd IF	330 kc
Input Impedance:	
600-ohm position	20,000 ohms nominal
135-ohm position	4,500 ohms nominal
Power Requirements:	7 size D cells
Current drain	20 ma nominal
Voltage range	
nickel-cadmium, rechargeable	8.75 to 8.4 volts*
zinc-carbon	10.5 to 8.0 volts*
	(*fully charged to discharged range)
Battery Life:	Approximately 100 hours
Overall Dimensions:	
Width	12 inches
Height	7.5 inches
Depth	7.5 inches
Weight	16 pounds

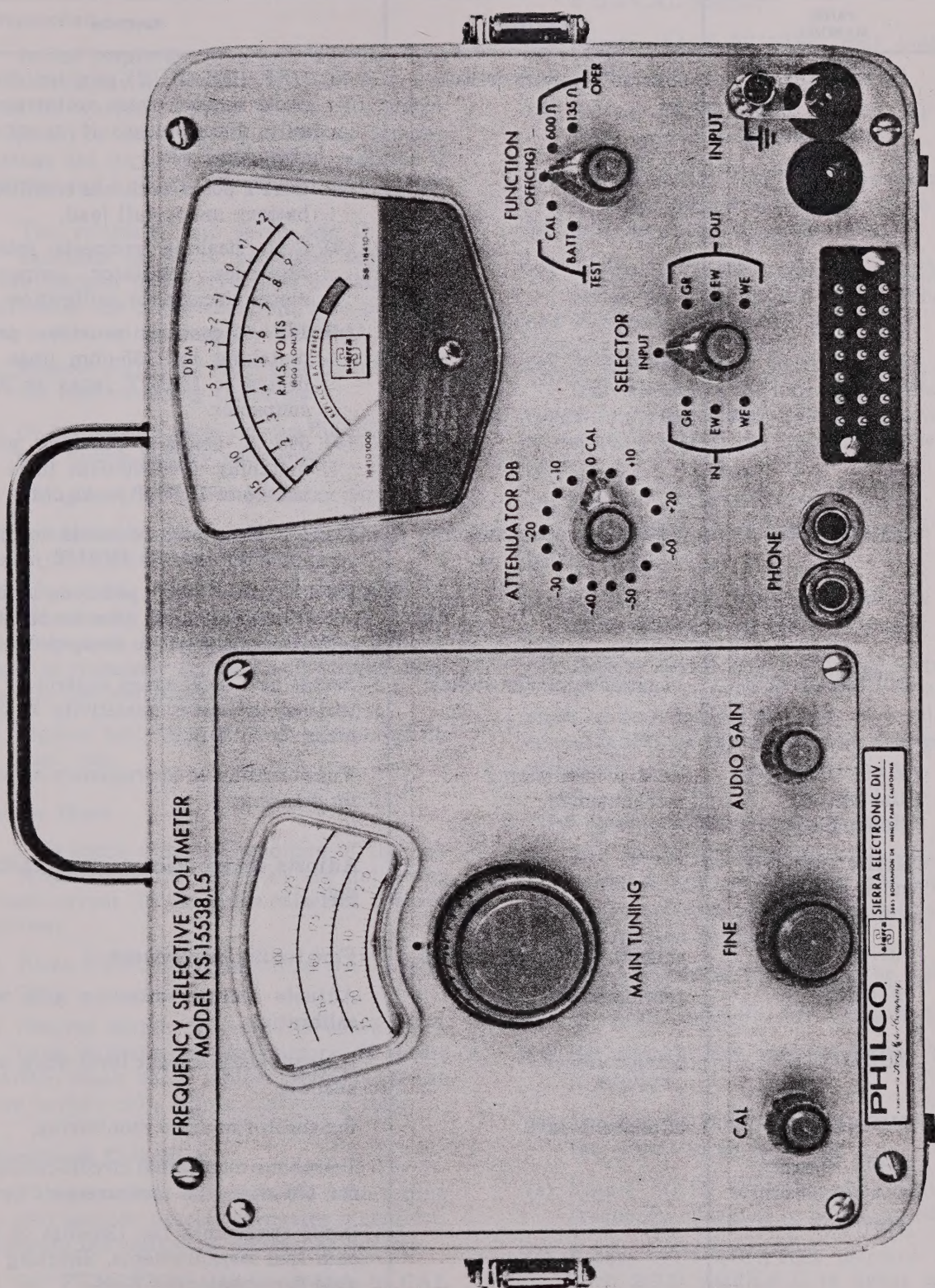

Fig. 1 – KS-15538,L5 Frequency Selective Voltmeter

TABLE 2 — OPERATING CONTROLS AND INDICATORS

PANEL MARKING	DESCRIPTION	FUNCTION
FUNCTION	5 position rotary switch	(1) OFF (CHARGE) position disconnects battery from voltmeter circuits and connects it to external charging jack. (2) BATT position checks condition of battery under full load. (3) CAL position connects internal reference oscillator output to meter circuits for calibration. (4) 135 Ω position provides proper matching for 135-ohm lines connected to INPUT jacks or 20-pin connector. (5) 600 Ω position provides proper matching for 600-ohm lines connected to INPUT jacks only.
SELECTOR	9 position rotary switch	(1) LINE position connects voltmeter input circuits to INPUT jacks. (2) IN and OUT positions connect voltmeter input circuits to 20-pin Western Electric connector.
ATTENUATOR	17 position rotary switch	Serves as a level range control by controlling voltmeter sensitivity in 5 DB steps up to 80 DB.
MAIN TUNING dial control (inner knob)	Gear driven tuning mechanism	Tunes voltmeter to frequency indicated on dial face.
MAIN TUNING index control (outer knob)		Adjusts index pointer when calibrating.
FINE	vernier tuning mechanism	Fine tuning adjustment.
IF GAIN	potentiometer	Adjusts overall voltmeter gain when calibrating.
AUDIO GAIN	potentiometer	Adjusts audio output level when using headset.
PHONE	headphone jack	Provision for audio monitoring.
20-pin Western Electric connector		Telephone directional circuit-connector for 135-ohm line measurement only.
INPUT		Input connectors for 135-ohm or 600-ohm line measurements. Shorting link used for unbalanced lines.

3. OPERATION

A. Preparation

3.01 ***Initial Inspection.*** The voltmeter has been thoroughly inspected at the factory and is covered by warranty. Prior to use, the instrument should be inspected for in-transit damage. If damage has occurred, it should be reported to the carrier and to Sierra Electronic Corporation.

3.02 The voltmeter and seven size D nickel-cadmium cells are packaged separately and are shipped in a corrugated container. To install either the nickel-cadmium cells provided or zinc-carbon cells, proceed as follows:

(a) Remove voltmeter from case by loosening the four retaining fasteners.

(b) On the battery pack, remove the six screws that fasten battery pack cover.

(c) Swing cover away from battery pack.

(d) Install cells being careful to observe polarity markings on battery pack.

Caution: The cells must be installed in accordance with the polarity markings on the battery pack. Improper installation will result in transistor burnout and serious damage to the instrument.

(e) Tighten battery pack cover screws and install case.

B. Battery Check

3.03 This check tests the condition of the batteries while the batteries are delivering full load current. To check the batteries, proceed as follows:

(a) Place FUNCTION switch to BATT position.

(b) Observe meter. If needle is above black band, batteries are satisfactory. If needle is within black band, replace or recharge the seven battery cells before continuing tests.

C. Operational Calibration

3.04 This procedure calibrates the main tuning dial and the overall voltmeter sensitivity. To calibrate the voltmeter, proceed as follows:

(a) Set FUNCTION selector switch to CAL position.

(b) Set ATTENUATOR selector switch to 0 DB CAL position.

(c) Rotate MAIN TUNING dial control to 25 KC.

(d) Adjust FINE tuning control for maximum indication on DBM meter.

(e) Adjust MAIN TUNING index control until index pointer is directly below the 25 KC mark on main tuning dial face.

(f) Adjust IF GAIN control for 0 DBM indication on DBM meter. The voltmeter is now calibrated for overall sensitivity.

(g) If it is desired to check the main tuning dial calibration for a particular frequency range, rotate the MAIN TUNING dial control to red mark nearest the frequency to be measured.

(h) Rotate ATTENUATOR selector switch until DBM meter indication is in upper half of scale.

(j) Adjust FINE tuning control for maximum indication on DBM meter.

(k) Adjust MAIN TUNING index control until index pointer is directly below red mark on main tuning dial face. The voltmeter is now calibrated for the frequency range to be measured.

D. Line Measurements — 20-Pin Connector

3.05 The 20-pin Western Electric connector is provided for patching into 135-ohm carrier lines. To perform 135-ohm carrier line measurements, proceed as follows:

(a) Patch voltmeter to circuit to be tested.

(b) Calibrate voltmeter per paragraph 3.04.

(c) Set FUNCTION selector switch to 135 Ω position.

(d) Set SELECTOR switch as required for the circuit to be measured.

(e) Rotate MAIN TUNING dial control to frequency of signal to be measured.

(f) Rotate ATTENUATOR selector switch until DBM reading is in upper half of scale.

(g) Adjust FINE tuning control for maximum indication on DBM meter.

(h) Read DBM meter indication. To obtain the input signal level, algebraically add the DBM meter indication to the attenuator setting.

E. Line Measurements — Input Jacks

3.06 The INPUT jacks are provided for making measurements on 135-ohm or 600-ohm, balanced or unbalanced lines. To perform line measurements, proceed as follows:

(a) Connect voltmeter to circuit to be tested. For unbalanced lines, use shorting link. For balanced lines, disconnect shorting link.

(b) Calibrate voltmeter per paragraph 3.04.

(c) Set FUNCTION selector switch to desired impedance setting (600 Ω or 135 Ω).

(d) Set SELECTOR switch to LINE position.

(e) Rotate MAIN TUNING dial control to frequency of signal to be measured.

(f) Rotate ATTENUATOR selector switch until DBM meter indication is in upper half of scale.

(g) Adjust FINE tuning control for maximum indication on DBM meter.

(h) Read DBM meter indication. To obtain the input signal level, algebraically add the DBM meter indication to the attenuator setting.

F. Headphone Monitoring

3.07 Provision is made to monitor audio signals that may be present on line signals under measurement. To monitor audio signals, connect a headphone set of any impedance to the jacks marked PHONES and adjust the AUDIO GAIN control for a suitable listening level.

4. THEORY OF OPERATION

A. General

4.01 The KS-15538, L5 voltmeter employs a dual conversion superheterodyne circuit to measure frequencies in the range of 2 KC to 350 KC with a bandpass of 500 cps. Fig. 2 illustrates a functional block diagram of the frequency selective voltmeter. Fig. 3 shows a complete schematic diagram of the voltmeter and includes levels at various points of the circuit. Refer to Fig. 2 for the general theory of operation and to Fig. 3 for the detailed theory of each module. At the input of the voltmeter, selector switches are used to select an input signal from either the 25 KC reference oscillator or from the front panel input connectors. A filter and matching network is incorporated in the input circuits to attenuate unwanted high frequency components and to provide proper input impedances.

4.02 To control the sensitivity of the voltmeter, a variable attenuator provides up to 80 DB of attenuation in 5 DB steps. Tuning of the voltmeter is accomplished by a variable oscillator that operates over the frequency range of 1310 KC to 1660 KC. Both the input signal and the variable oscillator signal are applied to a mixer stage where the first heterodyning action takes place to produce a 1310 KC difference frequency. The first i-f amplifier is tuned to 1310 KC and amplifies the output of the first mixer.

4.03 To improve image rejection, a second mixer stage heterodynes a 980 KC local oscillator signal with the first i-f signal to produce a 330 KC difference frequency. The 500 cps bandpass of the voltmeter is determined by a crystal filter located between the second mixer and the second i-f amplifier. After amplification by the second i-f amplifier, the signal is rectified and filtered in a meter detector circuit and then applied to the DBM meter.

4.04 The second mixer output is also fed through a ceramic bandpass filter to an audio circuit where audio components of the input signal are detected and amplified. Phone jacks are provided to connect headphones in the circuit for audio monitoring.

4.05 The reference oscillator generates a 25 KC square wave and is set to provide an output level that is equivalent to 0 DBM at the input connectors. Before voltage measurements are made, the voltmeter sensitivity is calibrated by connecting the reference oscillator output to the voltmeter input circuits and adjusting the second i-f amplifier gain for a 0 DBM indication.

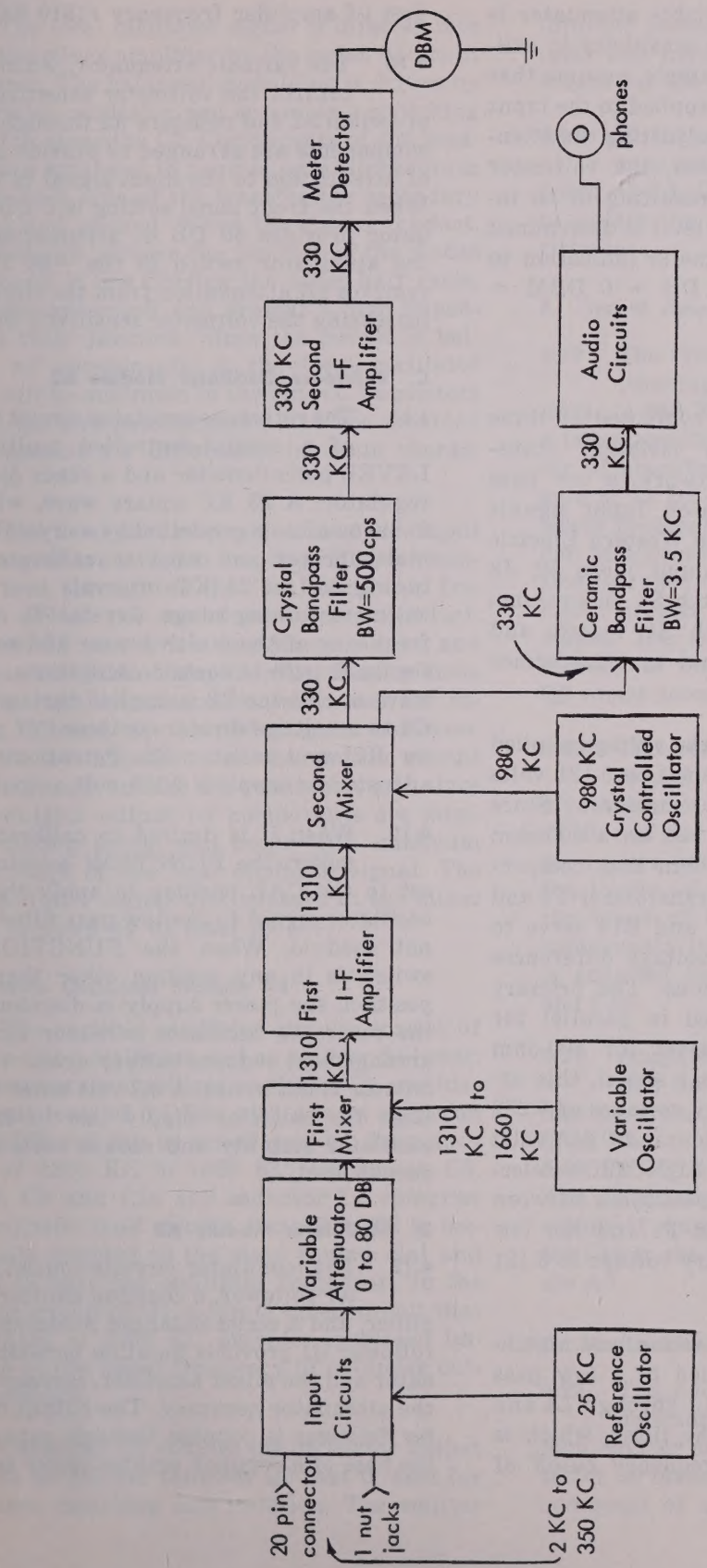

Fig. 2 – KS-15538,L5 Voltmeter Functional Block Diagram

4.06 When the voltmeter is used for voltage measurements, the variable attenuator is used to change the voltmeter sensitivity in calibrated steps of 5 DB. For example, assume that a signal level of −20 DBM is applied to the input of a calibrated voltmeter. By adjusting the attenuator to the −20 DB position, the voltmeter sensitivity increases 20 DB, resulting in an indication of 0 DBM. The input level is determined by algebraically adding the meter indication to the attenuator setting: −20 DB + 0 DBM = −20 DBM.

B. Input Module A1

4.07 The input circuits are composed of three selector switches, an isolation transformer, a filter matching network, a low pass filter, and an 80 DB attenuator. Input signals are applied to either the 20-pin Western Electric connector J1 or to the line input jacks J2, J3 and J4. The SELECTOR switch S3, in conjunction with FUNCTION switch S1, selects and applies the proper input signal to transformer T1.

4.08 During line operation, the voltage applied to the low pass filter must be 0.121 volts with 0 DBM at the input connectors. Since 0 DBM corresponds to 0.775 volt on a 600-ohm line and 0.367 volt on a 135-ohm line, compensation is necessary. Isolation transformer T1 and filter matching resistors R13 and R14 serve to compensate for input signal voltage differences between the two line operations. The primary windings of T1 are connected in parallel for 135-ohm operation and in series for 600-ohm operation. With a 0 DBM input signal, this arrangement results in secondary voltages of 0.232 volts for the parallel connection and 0.245 volts for the series connection. The FUNCTION selector switch inserts the proper resistance between the secondary of transformer T1 and the low pass filter to drop the secondary voltage to 0.121 volt.

4.09 After selection, compensation, and matching, the signal is applied to a low pass filter consisting of inductors L1 through L4 and capacitors C1 through C5. The filter, which is constant K derived, has a frequency cutoff of 500 KC and provides 60 DB of rejection to the first i-f amplifier frequency (1310 KC).

4.10 The variable attenuator, which is used to control the voltmeter sensitivity, consists of switch S2 and resistors R2 through R12. These components are arranged to provide up to 80 DB of attenuation to the input signal in 5 DB steps. When the front panel setting is 0 DB, the attenuator provides 60 DB of attenuation. Rotating the attenuator switch to the −60 DB position removes all attenuation from the circuit, thereby increasing the voltmeter sensitivity by 60 DB.

C. Reference Oscillator Module A2

4.11 The reference oscillator circuit is composed of a crystal-controlled multivibrator, a LEVEL potentiometer and a zener diode voltage regulator. A 25 KC square wave, which is rich in harmonics, is generated by a crystal-controlled multivibrator and used to calibrate the main tuning dial at 25 KC intervals over the entire voltmeter tuning range. Crystal Y1 controls the frequency of the multivibrator and serves as the feedback path to sustain oscillations. The square wave at resistor R8 is applied through capacitor C3 to a voltage divider composed of potentiometer R11 and resistor R9. Potentiometer R11 is adjusted to supply a 0.121 volt output signal.

4.12 When it is desired to calibrate the voltmeter, the FUNCTION selector switch is set to the CAL position to apply the reference oscillator signal to the low pass filter in the output module. When the FUNCTION selector switch is in any position other than the CAL position, the power supply is disconnected from the reference oscillator collector circuits. This arrangement reduces battery drain when the oscillator is not in use. A 6.2 volt zener diode regulates the collector supply line to improve the oscillator stability and reduce variations in the output level.

D. Modulator Module A3

4.13 The modulator circuits consist of an emitter follower, a common emitter mixer amplifier, and a series balanced modulator. Emitter follower Q1 provides isolation between the attenuator and the mixer amplifier, thereby preserving the attenuator accuracy. The output of the emitter follower is coupled through capacitor C3 to the base of a common emitter mixer amplifier.

4.14 The local oscillator signal is injected into the mixer amplifier by the series balanced modulator. The balanced modulator is driven by the variable oscillator and serves as a switching device for capacitor C7. Components of the modulator are arranged to provide equal impedances between each side of the transformer secondary winding and ground. When the diodes conduct, the impedance between the junction of the diodes and ground is low. During the other half cycle, the diodes are cutoff and present a high impedance at their junction. Since the circuit is balanced, r-f components of the local oscillator signal will be minimum in the output. Capacitors C8 and C9, and potentiometer R16 are provided to compensate for differences in diode characteristics.

4.15 The local oscillator signal and the input signal are mixed in amplifier Q1, with minimum feed through of the local oscillator frequency. When the modulator diodes conduct, capacitor C7 sees a low impedance return and increases the gain of amplifier Q1. During diode cutoff, a high impedance return is seen by capacitor C7 and the amplifier gain decreases. Since the a-c impedance of the emitter circuit is varying, and not the d-c resistance, and since the modulator output r-f components are minimum, mixing action will occur with minimum feed through of the local oscillator signal. The local oscillator signal that appears at the mixer output is down by at least 80 DB.

E. Variable Oscillator Module A4

4.16 The variable oscillator circuits consist of a clapp oscillator and an emitter follower. The temperature stabilized oscillator Q1 provides an output level of 0 DBM with a total variation of 0.25 DB and can be tuned over the frequency range of 1310 KC to 1660 KC. Capacitors C5, C6, C8, C9 and C14 and inductor L2 comprise the oscillator tank circuit. Capacitor C9 is mechanically coupled to the main tuning dial and is used to vary the oscillator frequency. In the collector circuit of Q1, a low Q tuned circuit that is resonant at 2000 KC provides increased impedance at the upper frequency to minimize output variations.

4.17 Capacitor C7 couples the oscillator output to an emitter follower Q2 that is used for impedance matching and isolation. The emitter follower presents a high impedance to the oscillator and appears as a low impedance driving source for the balanced modulator.

4.18 In the collector supply line of the reference oscillator, a decoupling network composed of L3, C11, C12 and C13, is incorporated to isolate the oscillator from the power supply circuits.

F. First IF Amplifier Module A5

4.19 The first i-f amplifier circuits consist of a two-stage 1310 KC i-f amplifier, a second mixer, a 980 KC second injection oscillator and a two-stage 330 KC i-f amplifier. Common emitter i-f amplifiers Q1 and Q2 provide an overall gain of 11 DB and employ both emitter and collector feedback to achieve gain stabilization under temperature and power supply variations. Double tuned transformers are used as resonant tank circuits and provide coupling between stages. The output of the i-f amplifiers is fed directly to the base of the second mixer stage Q3 where second conversion takes place.

4.20 The local oscillator signal that is used for second conversion is supplied by a 980 KC crystal controlled oscillator and is applied to the emitter of the mixer stage Q3. The second mixer produces a 330 KC second i-f frequency that is fed to the i-f amplifier module A7 and also to the input of Q4. Reduction of 980 KC signal components in the output circuit of mixer Q3 is achieved by a trap circuit composed of L7 and C14.

4.21 Amplifiers Q4 and Q5 provide amplification for the 330 KC second i-f signal and incorporate a ceramic ladder interstage bandpass filter FL1 to achieve the desired selectivity before the signal is coupled to the audio circuits. The output signal is developed in the collector circuit of amplifier Q5 and is coupled by capacitor C19 to the audio amplifier and detector module A6.

G. Audio Amplifier Module A6

4.22 The audio amplifier circuits consist of a detector and two audio amplifiers. Common emitter amplifier Q1, which serves as a detector, is biased near cutoff by a voltage divider composed of resistors R1 and R2. During the

positive half of the input cycle, amplifier Q1 is cut off and no output signal will appear across the collector load resistor R4. When the input signal is negative-going, the emitter to base circuit is forward biased, the collector current increases, and an output signal will be developed. Capacitor C9 is used to filter i-f components. Since the positive portion of the input signal is not developed in the output and filtering action is provided by capacitor C9, the audio component of the input will be detected by amplifier Q1.

4.23 Common emitter amplifier Q2 has a gain of 19 DB and incorporates a low-pass filter in its output to provide additional i-f filtering. Gain control R9 provides a means to vary the audio output drive to amplifier Q3. Common emitter amplifier Q3 provides a gain of 19 DB and operates only when headphones are plugged into jacks J6, J7, or both. Headphones are connected when audio monitoring is desired and serve as the collector load impedance for Q3. This arrangement reduces battery drain when audio monitoring is not used.

H. 330 KC Second I-F Amplifier Module A7

4.24 The second i-f amplifier circuits consist of a 330 KC i-f amplifier and a narrow bandpass crystal filter. Before amplification, the 330 KC i-f signal is applied to a 330 KC crystal filter that provides a 3 DB bandwidth of 500 cycles. This filter determines the overall selectivity. Three stages of i-f amplification are provided by broad-band amplifiers Q1, Q2, and Q3. Each amplifier uses a single tuned tank circuit, emitter feedback and capacitive coupling. In addition, amplifier Q3 incorporates an IF GAIN potentiometer for gain adjustments. The gains of the amplifier stages are +9 DB for Q1, +27 DB for Q2, and −4 to +26 DB for Q3. The overall gain, including input filter and crystal filter losses, is adjustable from +35 DB to +65 DB.

4.25 The collector supply line is decoupled by inductors L4, L5 and L6 and capacitors C12, C13 and C14 to prevent interaction between i-f amplifier stages. The output is coupled by capacitor C11 to the meter detector and amplifier A8.

J. Meter Amplifier and Detector Module A8

4.26 The meter amplifier and detector circuits consist of a common emitter amplifier and a half-wave rectifier. Common emitter amplifier Q1 provides 35 DB of gain and uses collector to base feedback to achieve gain stabilization. In the collector circuits of Q1, a decoupling network composed of inductor L1 and capacitors C6 and C7 isolates the amplifier from the power supply line. The output signal of amplifier Q1 is developed across the collector load resistor R5 and couples through capacitor C3 to a half-wave rectifier circuit.

4.27 Diode CR1 conducts on alternate half cycles to develop a negative d-c voltage across a voltage divider composed of resistors R6, R7 and R8. Filtering of the i-f components is provided by capacitors C4 and C5. The resultant d-c output is applied to a microammeter which is calibrated to indicate the voltmeter input level in DBM or in volts. The DBM scale is valid for both 600-ohm and 135-ohm line measurements. The voltage scale is used only when the voltmeter is measuring 600-ohm lines.

K. Power Supply Circuits

4.28 The power supply circuits consist of seven 1.5 volt size D cells connected in series to provide a nominal supply voltage of 10.5 volts. Since the voltmeter circuits use p-n-p transistors that require a negative collector voltage, the positive terminal of the battery is grounded. The negative terminal is connected to the wiper of FUNCTION selector switch S1-C.

4.29 When the selector switch is in the BATT position, the switch connects the power supply to the junction of resistors R7 and R8 in the meter amplifier and detector module. In this mode of operation, resistor R8 draws 18 milliamperes to load the battery and resistor R7 provides the proper multiplier resistance.

4.30 Placing the FUNCTION switch to either the 135 Ω or the 600 Ω position, connects the battery to all modules except the reference oscillator.

4.31 When the FUNCTION switch is in the CAL position, the battery is connected to all modules of the voltmeter.

4.32 The battery is disconnected from the voltmeter circuits and connected to the external charging jack when the FUNCTION switch is in the OFF (CHARGE) position.

5. MAINTENANCE

5.01 All maintenance and internal calibration of the KS-15538, L5 voltmeter should be performed by Red Ball or equivalent service. These locations will perform all tests and repairs using the instruction manual issued by Sierra Electronic Division of Philco Corporation.

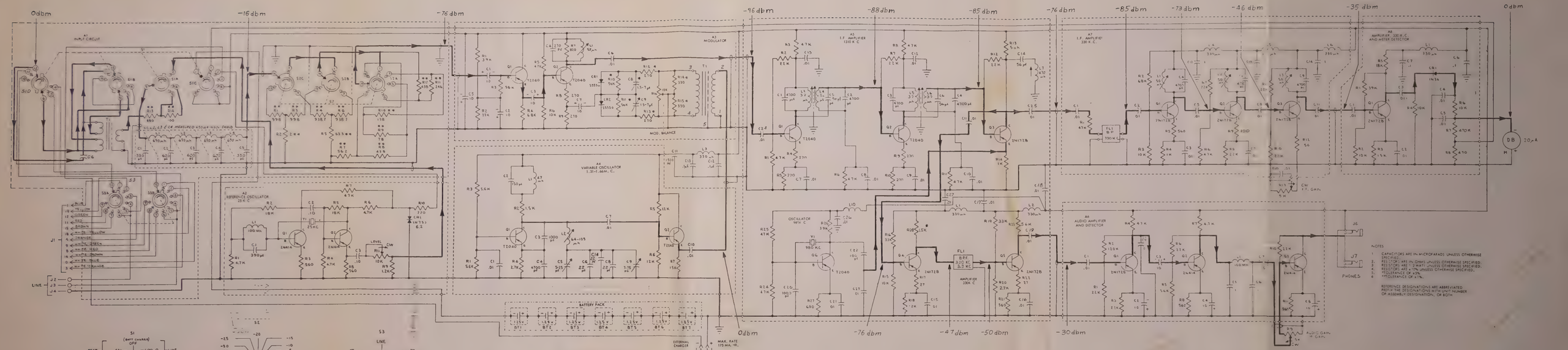

Fig. 3 – KS-15538,L5 Voltmeter Schematic Diagram

KS-15538, LIST 5 CARRIER FREQUENCY VOLTMETER

(RANGE: 2 TO 350 KILOCYCLES)

DESCRIPTION

(SIERRA ELECTRONIC CORPORATION)

1. GENERAL

1.001 This addendum supplements Section 103-400-105, Issue 1.

1.002 This addendum is issued for the following reasons:

(a) To add a bridged reading notation to Table 1, Table 2, paragraph 3.05, and paragraph 3.06.

2. CHANGES TO SECTION

2.001 On Page 2, Table 1, change ***Direct Reading:*** to read DBm on 135-ohm and 600-ohm bridged readings, balanced or unbalanced lines. Voltage on 600-ohm lines only.

2.002 On Page 4, Table 2, change the column designated FUNCTION, item (4), to read: 135 Ω position provides proper matching for 135-ohm lines connected to INPUT jacks or 20 pin connector. (Meter indicates bridged reading values.)

2.003 On Page 6, following paragraph 3.05 (h), add:

Note: Meter indicates bridged reading values.

2.004 On Page 6, following paragraph 3.06 (h), add:

Note: Meter indicates bridged reading values.

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